SOME METHODS USED IN REPRESENTING BATHYTHERMOGRAPH DATA

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College Station, Texas

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Project 29

SOME METHODS USED IN REPRESENTING BATHYTHERMOGRAPH DATA

(Technical Report No. 1)

Project 29 is a study of the atmospheric influence on the thermal structure of the oceans, sponsored by the Office of Naval Research (Project NR 083-061, Contract N7onr-487, Task Order 3). The work reported herein is of a preliminary nature and the results are not necessarily in final form.

Report Prepared May 1, 1952

by

DALE F. LEIPPER AND RICHARD M. ADAMS

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ABSTRACT

In the study of the atmospheric influence on the thermal structure of the oceans, the bathythermograph (BT) temperature-depth data collected at the fixed locations of the weather patrol vessels in the Atlantic and Pacific Oceans provide probably the best pertinent series of data covering long periods of time.

Approximately 15,000 of such weather station BT observations are now available for the North Atlantic alone. These cards covering the period from 1945 to 1950 in the Atlantic are distributed primarily over six weather stations which are shown in Figure 1. The object of this report is to describe the various methods used in putting the patrol vessel data into a form suitable for analysis directed toward the objectives of the present project. Portions of the data for Station E (35°00' N, 48°00' W) are represented in the figures which are used to illustrate the different forms of data presentation. Station E was selected because of the relatively good series of observations obtained there. The various forms of presentation are used to bring out significant features of the thermal variation which are of such a nature as to permit their association and correlation with atmospheric phenomena which may be predicted.

It is planned that all data collected at the on-station positions of the weather patrol vessels of the Atlantic and the Pacific be summarized in the fashion described here and presented for limited distribution in two subsequent data reports.

SURFACE TEMPERATURE STUDY

As is well known, there often exists considerable discrepancy between the surface temperature read from the BT card and that recorded by the observer using a mercury sea temperature thermometer at the time of the BT

lowering. In most instances, the bucket or injection temperature is often read to the nearest whole degree, thus introducing an error as great as ± 0.5°F. An even more serious difficulty, however, seems to be that surface bucket temperatures are not taken with each BT lowering. This is evidenced for example by the fact that the recorded values of surface temperature are often identical over a long period of time, while the BT surface temperatures show the variations which would be expected. The explanation seems to be that the surface temperature is often obtained not by actual observation but by copying the temperature for the preceeding BT lowering from the log sheet. However, it is assumed that these sea surface temperatures, obtained by reading a thermometer, would have random errors and would therefore give an indication of the validity of the BT readings for the same observations. Thus, for stations A, B, C, D, E, and H the average daily values of the bucket and BT surface temperatures were plotted for the year 1949-50. In those instances in which decided but fairly constant differences existed between the two curves for a group of observations taken with the same instrument, an average BT correction factor was obtained and applied to all temperature readings taken from those observations. When a noticeable change in the average difference between the two curves occurred or when a different instrument was used, a new correction factor was computed and applied.

Figure 2 illustrates the differences between bucket and BT surface temperatures and shows the corrected curve. Where no corrected temperature curve is shown on the graph, the bucket and BT temperatures are in close enough agreement on the average that the BT temperatures are considered to be the true values.

Another means of obtaining a corrected time graph of the BT surface temperatures was tested. The temperatures were read from the cards and plotted with no correction applied. The graphs were then smoothed by raising or lowering those sections of the curve which did not follow the regular pattern of the remaining values as shown in Figure 3. However, this method was not as satisfactory as the first since variations occurred in such a manner that the decision as to which section of the curve to adjust was difficult and arbitrary. Moreover, variations which actually did occur could be assumed to be calibration errors and therefore neglected by using this method.

TEMPERATURES AT SELECTED DEPTHS

In making a study of a group of BT cards covering a period of time, the question always arises as to whether or not to use all cards. At first thought it might seem that all cards should be read and an average determined for each day or other subdivisions of time. However, in a study of any feature which is characterized by diurnal changes as well as by changes over a longer time interval, this method might yield misleading results due to the fact that the observations seldom are uniformly spaced throughout the day and that observation times and frequencies on one day might be entirely different from those on another day. The time of most frequent daily observation for the Atlantic was 1200 hours (GCT). When only one observation per day was made, it was generally made at this hour and when more than one observation per day was taken, they were generally grouped around the 1200 hour. Only one card per day was used in this study, the one at 1200 hours usually being selected when available and the hour closest to that time when it was not available. Exceptions to this rule

occurred when with several observations for a given day the 1200 hour card differed (as to surface temperature, depth of thermocline, etc.) markedly from the others. In these cases, a typical card was chosen. If large internal waves were in evidence the typical card was selected as one at the nodal point of the wave. From these selected cards temperature readings were taken at ten chosen depths (0,25,50,75,100,150,200, 250, 350, and 450 feet). The values for the surface, 100 feet, 200 feet, and 350 feet readings were then plotted against time. These day by day observations showed quite sharp and erratic variations as illustrated in Figure 4. It was assumed that some of these changes were not associated with predictable atmospheric variations. To obtain a variation which would more clearly show the progressive nature of the temperature changes and emphasize the features which were probably related to atmospheric influences, the temperature values were smoothed by using continuous five point running averages. For example, the value for any given day was determined by averaging the value for that day with the values for the two preceeding days and the two following days. A comparison of figures 4 and 5 indicates the effect of this smoothing. At the beginning or end of a series of days and at places where data were missing, four day and in a few cases three day averages were used. Days for which no data are available are indicated on the graphs.

MIXED LAYER DEPTHS

The criterion used in determining the depth of the mixed layer was a 0.3°F change from the surface temperature. Often it was not necessary to use this criterion since the mixed layer was quite distinct and was followed by a strong thermocline.

The depth of the mixed layer normally increases during the winter season. In the higher latitudes the winter depth is often greater than 450 feet. Thus the ordinary deep or 450' BT cannot reach the thermocline and the mixed layer depth usually could not be determined during this season. For this reason it seems that in the higher latitudes during the winter months or whenever there is a large mixed layer depth the 900' BT should be used when feasible rather than the 200' or 450' BT. Many hundreds of BT observations have been made that give little or no information other than the fact that the water is well mixed at a given temperature to the depth to which the BT was lowered. Use of the 900' BT would in most cases show the depth to which this mixing extended and would greatly increase the value of the observations.

In conjunction with the reading of mixed layer depth, the gradient in the thermocline was noted. This was done by plotting the depths of those points on the BT traces at which the temperature was exactly two degrees lower than that of the waters at the bottom of the mixed layers. (Figure 6) These values, as well as those for the mixed layer depth, were smoothed in the same manner as were the temperatures at selected depths.

Other representations considered were plots of the mixed layer depth along with plots of the depths at which temperatures one degree lower than the surface temperature occurred and plots of original and smoothed values of the mixed layer depth. (Figures 7 & 8)

DEPTHS TO SELECTED DIFFERENCES FROM SEA SURFACE TEMPERATURE

A plot was made of the depths at which temperatures differing from the surface temperature by 1, 2, 4, 6, ... degrees Fahrenheit occurred. In Figure 9, D_1 designates that depth at which a temperature one degree

different from the surface temperature occurs: D_2 the depth of a two degree difference, and so on. The same type smoothing was used in this case as was explained above. This type of representation has the advantage of being independent of absolute values of temperature.

SUMMARY

As a result of studying various forms of representing the temperature data, three types of plots have been chosen to picture the thermal character of the oceans for the purposes of this project. These are:

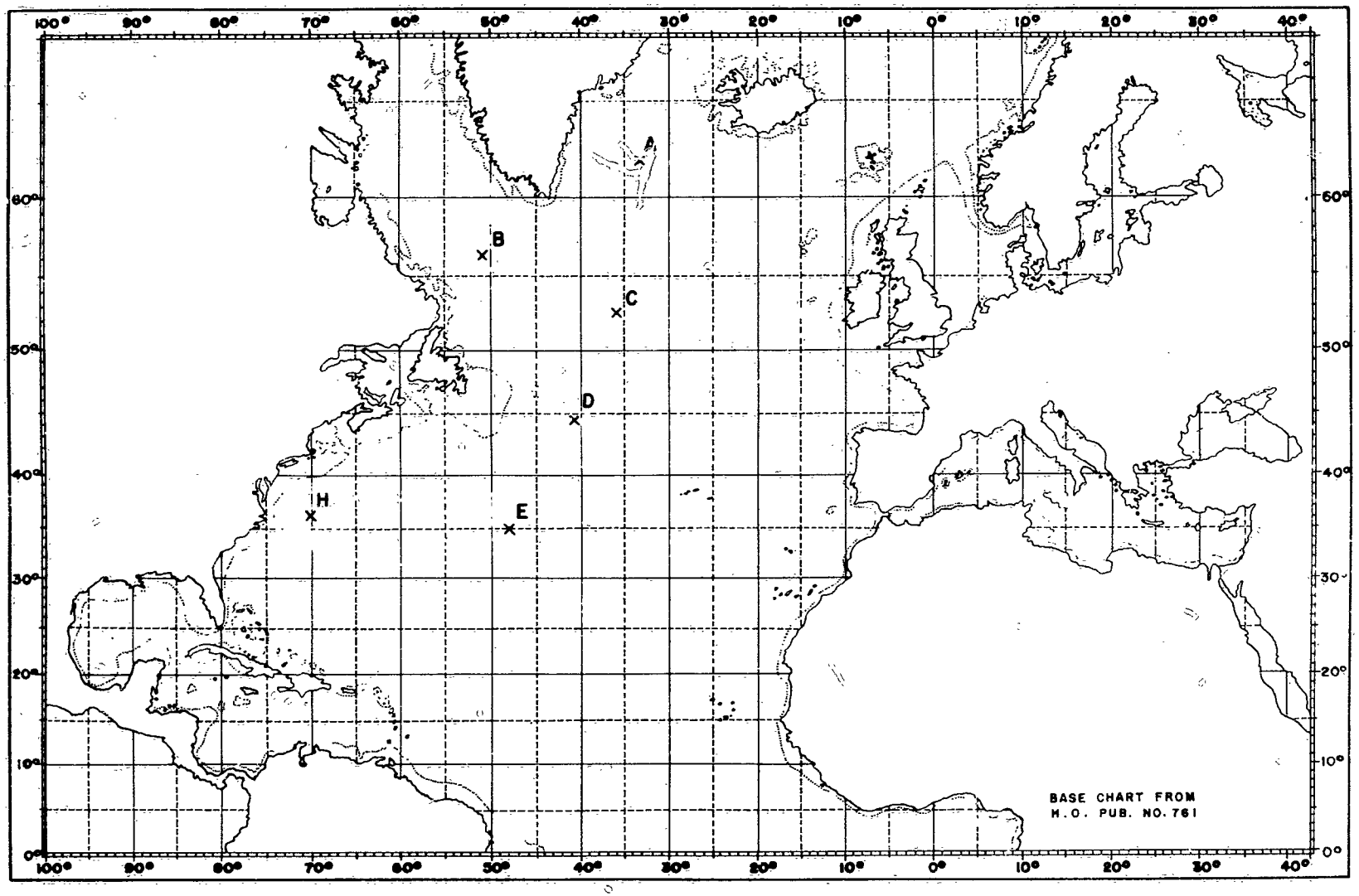
(1) Depth of mixed layer and of water 2° colder than the mixed layer

(2) Temperatures at selected depths; and

(3) Depths to selected differences from sea surface temperature.

The remaining Atlantic data for the year 1949-50 and for all other years having fairly continuous data have been worked up in this manner for the six stations indicated. All data are plotted in the smoothed form, the method of smoothing being the five day running average outlined above. Work on the Pacific data is beginning. Comments upon the methods described here are invited.

It is hoped that the data reports which are being prepared will, in addition to serving the needs of the present project, make the BT information from the weather patrol vessels available to many investigators who have previously not had access to it. This should stimulate research at the fixed station positions and lead to greatly increased information about the processes related to temperature changes in the sea.



LOCATION OF WEATHER STATIONS

FIGURE 1

SEA SURFACE TEMPERATURES

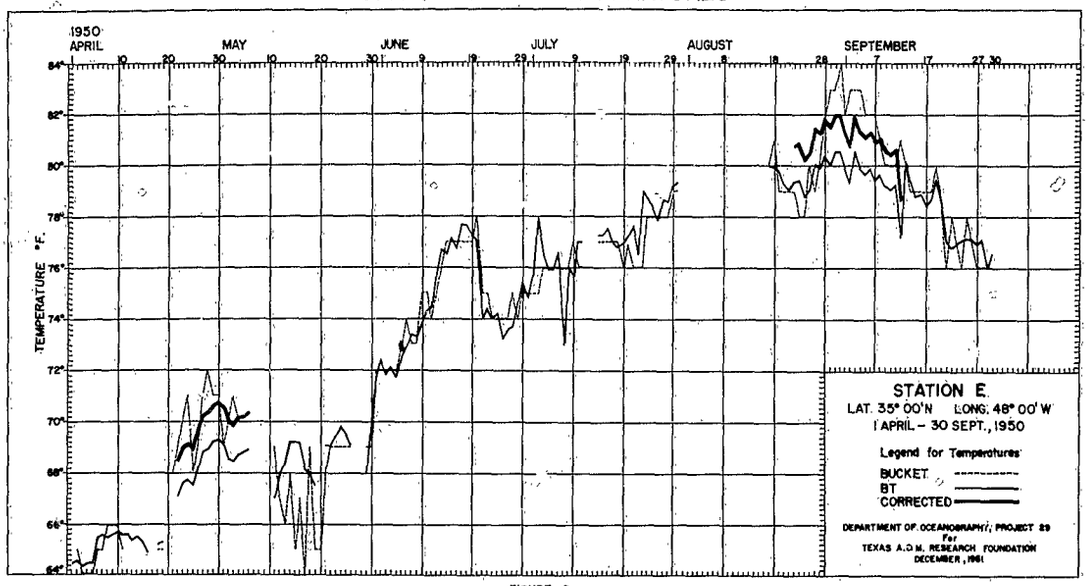


FIGURE. 2

SEA SURFACE TEMPERATURES

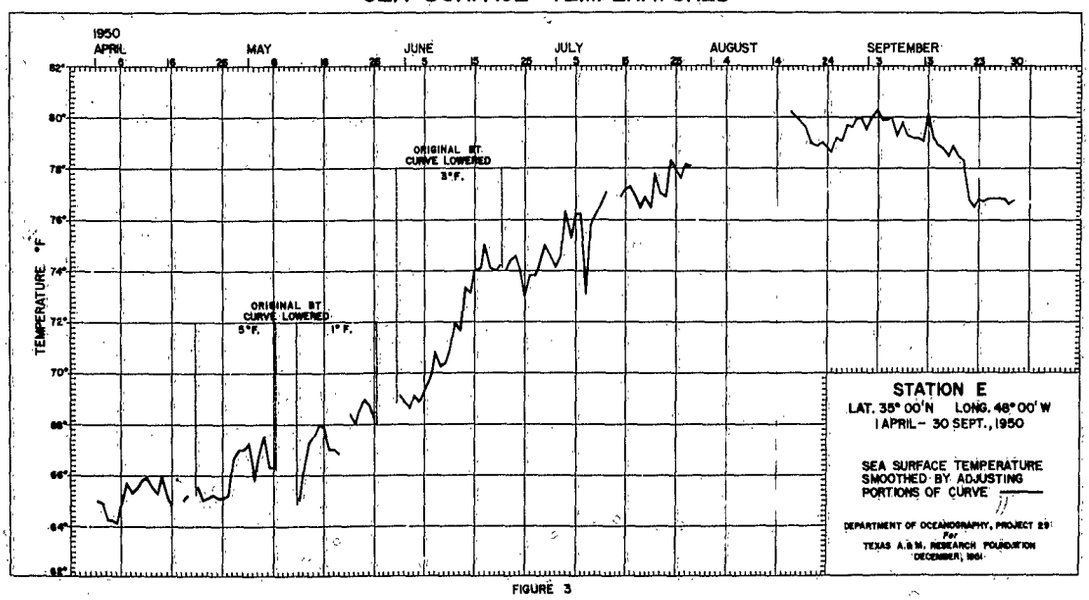


FIGURE 3

DEPTH OF MIXED LAYER AND OF WATER 2° F COLDER THAN MIXED LAYER

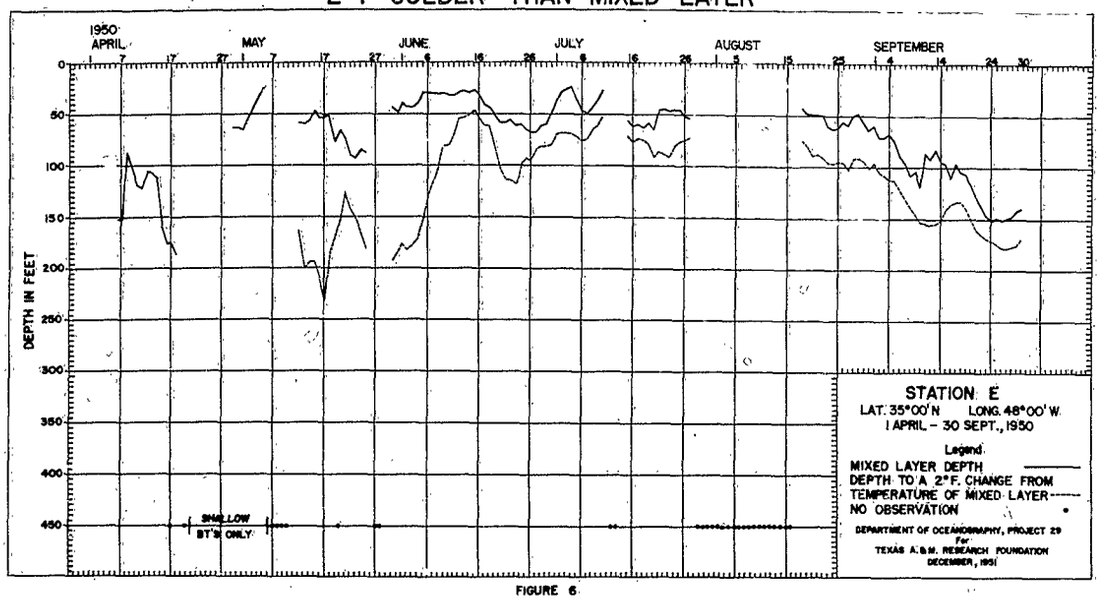


FIGURE 6

DEPTH OF MIXED LAYER AND OF A 1° F CHANGE FROM SURFACE TEMPERATURE

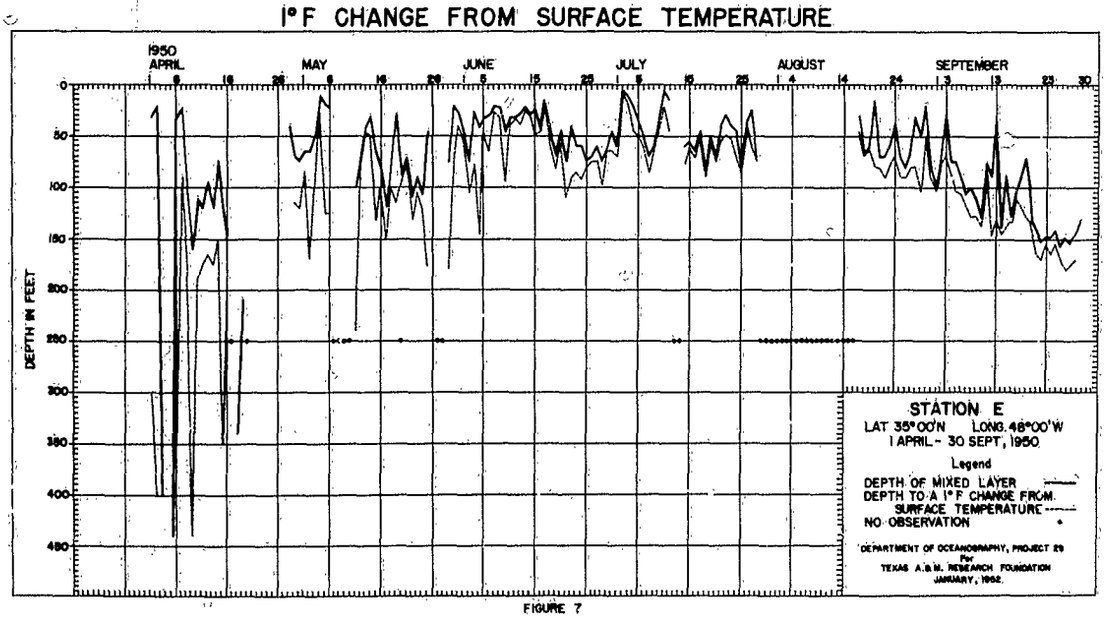


FIGURE 7

MIXED LAYER DEPTH, ORIGINAL AND SMOOTHED

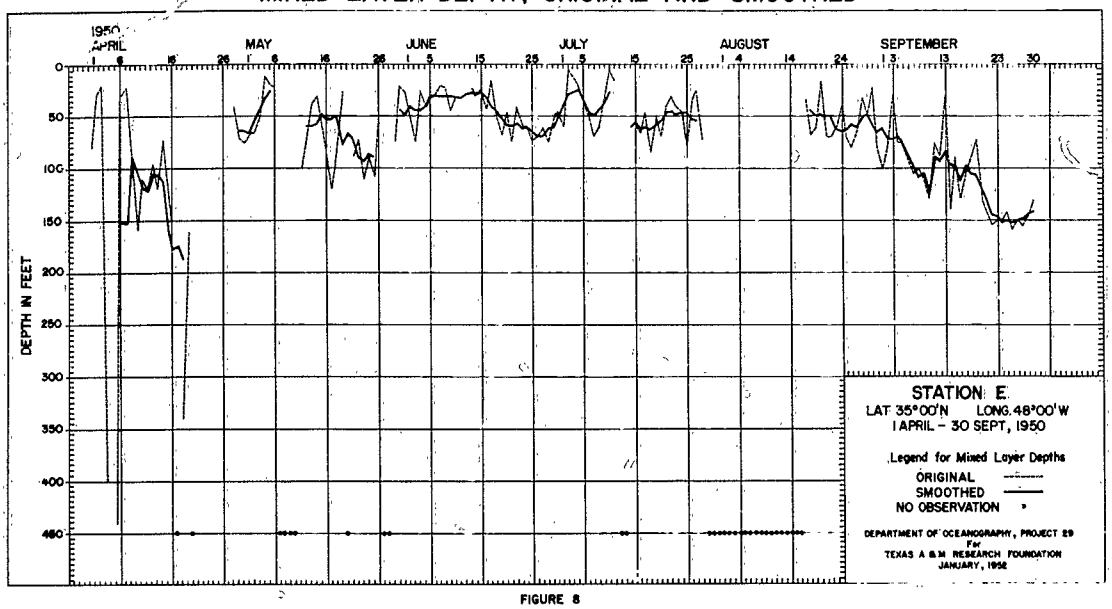


FIGURE 8

DEPTHS TO SELECTED DIFFERENCES FROM SEA SURFACE TEMPERATURES

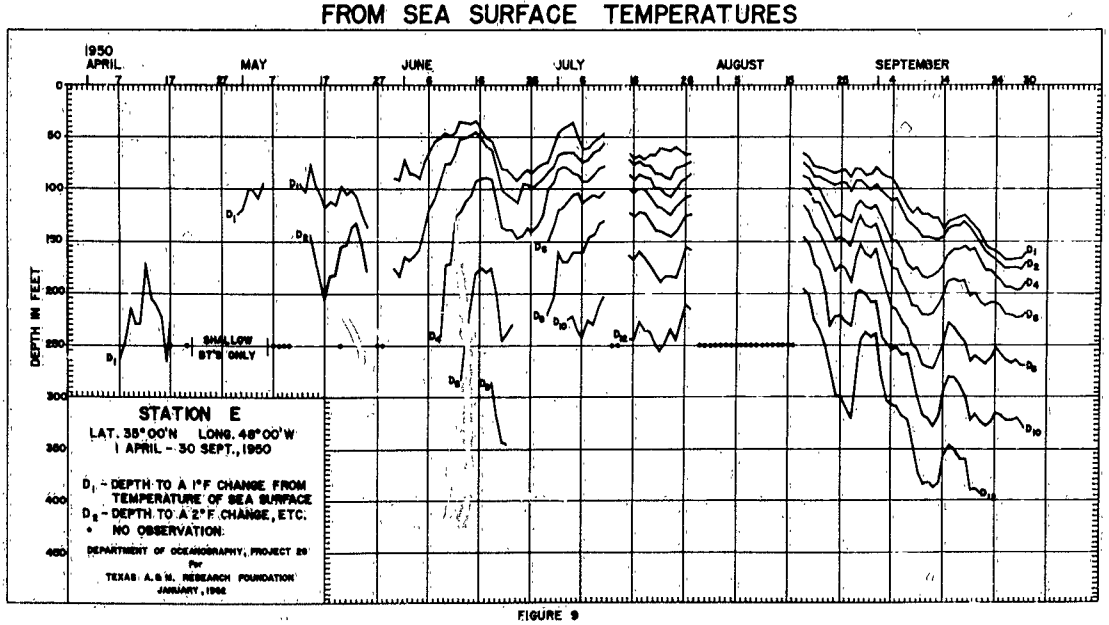


FIGURE 9

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